REMARKS

Claims 3, 4, 7, 8, 16-19, 23, 24, 27 and 28 directed to the structure of a copper alloy sputtering target are pending. Applicants submit arguments for overcoming the rejection based on the prior art of record. Accordingly, Applicants respectfully submit that the present application is in condition for allowance.

I. Claim Rejections – §103(a)

> *In the FINAL Office Action dated September 2, 2009, claims 3, 4, 7, 8, 16-19, 23, 24, 27 and 28 are rejected under §103(a) as being obvious over JP 06-177128 A in view of U.S. Patent No. 6,451,135 B1 issued to Takahashi et al..*

A full English language translation of JP '128 is provided by corresponding European publication EP 0601509 A1. This reference discloses a copper alloy sputtering target containing 0.02 to 20 atomic percent of aluminum.

In the Final Office Action, JP '128 is combined with the Takahashi et al. patent, which is directed to a high purity copper sputtering target. For example, see the title, abstract and column 1, line 5, of the Takahashi et al. patent. Also, see column 2, lines 66-67, which states "The high purity copper sputtering target of this invention has an impurity content reduced to a minimum" and column 3, lines 48-49, which states "The overall copper purity, excluding the gaseous ingredients, should be at least 99.999%."

Thus, there should be no mistake that Takahashi et al. provides a teaching to one of ordinary skill in the art that aluminum is considered an impurity and that the high purity copper sputtering target should contain no more than 1ppm of Al. (For instance, see the abstract of the Takahashi et al. patent.) Also see column 3, lines 23-35, which states:

> "... other impurities must also be minimized. Generally, electric resistance is a function of the impurity level and the smaller the impurity content the lower the electric resistance. Thus, in order to lower the electric resistance, a higher purity is desirable. When the actual cost of producing a sputtering target and other considerations are taken into account, it would be of great practical value to control the impurity level so that the resulting thin film shows an electric resistance **below 2.0μΩ·cm**.
>
> Thus not only the heavy metal elements but also such light metal elements as **Al**, Ca, Mg must be reduced in proportions, to 1ppm or less, preferably **0.1ppm or less**, each."

Thus, it is clear that one of ordinary skill in the art would view the teachings of Takahashi et al. as being contradictory to JP '128. In Takahashi et al., aluminum is clearly an impurity which must be reduced such that its content is no more than 0.1ppm.

Applicants respectfully request reconsideration and removal of the above referenced rejection for each of the following reasons:

(i) It would not be obvious for one of ordinary skill in the art relying on common sense to combine references providing contradictory teachings;

(ii) The disclosure provided by Takahashi et al. expressly teaches away from the composition required by JP '128 and the claims of the present application which provides a *per se* demonstration of lack of obviousness;

(iii) A modification of the sputtering target of one of the cited references based on the other of the cited references would destroy the intent, purpose and function of the invention disclosed in one of the references and, for this reason, would not be obvious;

(iv) The specific range required by the claims of the present application provides an unexpected result and is not obvious in view of the teachings of the cited references;

(v) The claim limitations requiring the target to have a structure "that does not substantially contain any precipitates" or that contains "no precipitates" is not disclosed by the cited references nor would such a property be expected; and

(vi) The claim limitation requiring the target to have a structure with a ratio I(111)/I(200) of 2.2 or more in its sputtering face is not disclosed by the cited references nor would such a property necessarily be expected.

(i) Not Obvious to Combine References Providing Contradictory Teachings

In the FINAL Office Action, the references are combined simply on the basis of being in the same field of endeavor or in an analogous metallurgical art irrespective of the actual disclosures provided by the references. Applicants respectfully submit that the actual specific disclosures and details of the references must be considered to see whether or not such references provide teachings that are obvious to combine and that their simple combination without such consideration is error. For this reason, Applicants respectfully request reconsideration.

One of the cited references specifically requires a sputtering target made of a copper alloy (Cu and Al) and the other specifically requires a sputtering target made of pure copper (in which Al content should be 0.1ppm or less and is considered an undesired impurity). Thus, the references provide contradictory teachings of which it is only possible to follow one by one of ordinary skill in the art. Thus, while both references disclose sputtering targets, one of ordinary skill in the art is not able to readily combine their teachings due to the contradictory nature of the teachings provided by the references. Accordingly, Applicants respectfully submit that a proper *prima facie* case of obviousness cannot be made under 35 USC §103(a) with JP '178 in view of the Takahashi et al. patent because one of ordinary skill in the art using common sense at the time of the invention would not have reasonably combined the teachings of JP '128 with that of Takahashi et al. due to the opposite teachings.

JP '128 is directed to a technology for forming, via sputtering, a thin film which itself provides copper wiring. JP '128 teaches that this thin film copper wiring must have superior oxidation resistance which is obtained by oxidizing an alloy added with a specific element. More specifically, JP'128 requires its copper alloy sputtering target to contain up to 20wt% of Al for the purpose of providing oxidation resistance.

In direct contrast, the Takahashi et al. patent relates to a technology for preventing an increase in electrical resistance by inhibiting impurity content of the copper target. Accordingly, Takahashi et al. teach that no significant amount of Al should be permitted in the copper sputtering target.

More specifically, the Takahashi et al. patent teaches to one of ordinary skill in the art that (see column 2, line 66, to column 3, line 52):

> "The high-purity copper sputtering target of this invention has an impurity content reduced to a minimum.
>
> In order to ensure the reliability of performance of a semiconductor device formed by sputtering, it is important to minimize the proportion of impurities deleterious to semiconductor devices. …
>
> Besides these elements, particularly those harmful to semiconductor elements, other impurities must also be minimized. Generally, electric resistance is a function of the impurity level and the smaller the impurity content the lower the electric resistance. Thus, in order to lower the electric resistance, a higher purity is desirable. When the actual cost of producing a sputtering target and other considerations are taken into account, it would be of great practical value to control the impurity level so that the resulting thin film shows an electric resistance below 2.0 $\mu\Omega\cdot$cm.
>
> Thus not only the heavy metal elements but also such light metal elements as Al, Ca, Mg must be reduced in proportions, to 1 ppm or less, preferably 0.1 ppm or less, each."

Accordingly, Takahashi et al. disclose a high purity copper sputtering target without impurities and specifically define Al as an impurity. The content of Al is required to be less than

1ppm. In the Examples provided in Table 1 of Takahashi et al., each of the Examples and Comparative Examples includes no more than 0.05 ppm of Al. Further, Takahashi et al. specifically teach and require that the "films formed using the high-purity copper sputtering targets according to the invention had very low resistivities of <u>no more than 2.0 μΩ·cm.</u>" (See column 7, lines 57-59, of Takahashi et al.)

Accordingly, Takahashi et al. provide a contradictory teaching relative to JP '128 (which requires up to 20wt% Al). One of ordinary skill in the art is taught by Takahashi et al. not to include significant amounts (i.e., no more than 1ppm) of Al so that a desired low resistivity (no more than 2.0 μΩ·cm) is attainable. In contrast, one of ordinary skill in the art is taught by JP '128 that up to 20wt% of Al must be included for purposes of providing oxidation resistance.

One of ordinary skill in the art would clearly ascertain that you cannot have both the low resistivity (required by Takahashi et al.) and high oxidation resistance (required by JP '128). Thus, it would not be obvious for one of ordinary skill in the art to modify JP '128 according to the contradictory teachings of Takahashi et al. patent.

Accordingly, for at least the above stated reasons, Applicants respectfully submit that JP '128 and the Takahashi et al. patent provide contradictory teachings that would not be obvious to combine by one of ordinary skill in the art using common sense.

<u>(ii) Takahashi et al. Teaches Away from JP '128 and the Claimed Invention</u>

In the FINAL Office Action, Takahashi et al. is relied upon to reject the claims of the present application despite providing a teaching to one of ordinary skill in the art would teaches away from the teachings of JP'128 and teaches away from the subject matter claimed by the claims of the present application. **<u>"Teaching away"</u>** is the antithesis of the art suggesting that the

person of ordinary skill in the art go in the claimed direction. Essentially, "teaching away" is a per se demonstration of lack of obviousness. In re Fine, 873 F.2d 1071, 5 USPQ2d 1596 (Fed. Cir. 1988).

The above referenced rejection requires the teachings of Takahashi et al. to be applied to that of JP 06-177128. However, the disclosure of Takahashi et al. **expressly** directs one of ordinary skill in the art away from such a combination and away from the structure and composition required by the claims of the present application.

On column 1, lines 5-39, the disclosure of Takahashi et al. discusses "copper wiring materials". On column 1, lines 40-45, Takahashi et al. specifically cites and discusses the JP 06-177128 reference. For example, the Takahashi et al. reference states:

> "***Patent Application Kokai No. 6-177128*** discloses a thin film wiring material of a copper alloy containing 0.02-20 atom % Al or Si. The alloy is oxidized to form an oxide film in which Al or Si is diffused and concentrated on the wiring surface so as to enhance the oxidation resistance of the surface."

Thereafter, on column 1, lines 46-52, the Takahashi et al. reference teaches that there are disadvantages with the copper alloy thin film of JP 06-177128. For example, the Takahashi et al. reference states that:

> "A ***major problem*** common to the abovementioned methods is an increase in electric resistance by the addition of another element. An increased electrical resistance retards signal transmission and adds to power consumption. For this reason, it has been necessary to put an upper limit to the proportion of the additional element so that the electrical resistance is as low as that of pure Al, i.e., 2.7μΩ·cm or less."

Thereafter, the Takahashi et al. reference teaches a specific limit with respect to Al content. For example, on column 2, lines 20-32, and on column 3, lines 22-35, the Takahashi et al. reference discloses that Al is considered an "impurity" that "***must*** also be minimized." The

Takahashi et al. reference teaches that "light metal elements" such as Al "***must*** be reduced in proportions, to **1 ppm or less**, preferably 0.1 ppm or less".

Accordingly, the Takahashi et al. reference specifically identifies JP '128 and its inclusion of Al, identifies specific problems relative to JP '128 and its Al content, and **<u>expressly teaches away</u>** from the Al content taught by JP '128 whereby it requires Al content to be 1 ppm or less. The Takahashi et al. reference requires the use of virtually no Al in a copper sputtering target for forming thin film copper wiring. Thus, one of ordinary skill in the art is taught by Takahashi et al. not to use the teachings of JP '128. Accordingly, it would certainly not be obvious for one of ordinary skill in the art to modify JP '128 based on Takahashi when specifically taught by Takahashi et al. not to follow the teachings of JP '128.

For at least this reason, Applicants respectfully request reconsideration and removal of the obvious rejection of the claims of the present application based on the Takahashi et al. patent teaching away from the sputtering target of JP '128 and the sputtering target required by the claims of the present application.

<u>(iii) Required Modification would Destroy Intent, Purpose, or Function of Prior Art</u>

When a §103 rejection is based upon a modification of a reference that destroys the intent, purpose, or function of the invention disclosed in the reference, such a proposed modification is not proper and a *prima facie* case of obviousness cannot be properly made. <u>In re Gordon</u>, 733 F.2d 900, 221 USPQ 1125 (Fed. Cir. 1984).

If JP '128 is modified according to the teachings of Takahashi et al., this would require Al content to be reduced to a minimum (1ppm or less). (See express teachings of Takahashi et al. stated above.) Such a modification would destroy the intent, purpose, and function of the

sputtering target required by JP '128 which is utilized to produce wiring having resistance to oxidation.

Alternatively, if the pure copper sputtering target of Takahashi et al. is modified such that it includes more than 1ppm of Al according to the teachings of JP '128, it would no longer be able to prevent an increase in electrical resistance by inhibiting impurity content of the copper target. Such a modification would destroy the intent, purpose, and function of the sputtering target required by the Takahashi et al. patent.

Accordingly, modifying one of these contradictory teachings based on the other would require the intent, purpose, and function of the invention disclosed by one of these referenced to be destroyed. Of course, when a §103 rejection is based upon a modification of a reference that destroys the intent, purpose or function of the invention disclosed in the reference, such a proposed modification is not proper and a *prima facie* case of obviousness cannot be properly made.

For at least this reason, Applicants respectfully request reconsideration and removal of the obvious rejection of the claims of the present application.

(iv) Specific Range Claimed is Not Obvious and Provides Unexpected Results

As discussed above, JP '128 discloses a copper alloy sputtering target containing 0.02 to 20 atomic percent of aluminum.

In contrast, independent claims 3 and 7 of the present application require a copper alloy sputtering target containing 0.2 to 5wt%, which corresponds to 6.45 to 11.03 atomic percent. Of course, claims 4 and 8 of the present application further restrict this range to 0.5 to 1wt% of Al,

and independent claim 28 requires "a sputtering target body consisting of copper and 0.5 to 1 wt% of Al.

Applicants respectfully submit that the present invention requires numerical limitations with respect to Al content that results in unexpected results and yields an extremely superior effect that is not obvious from the wide range of Al content (0.02 to 20 atomic percent) taught by JP '128. Applicants respectfully submit that the specifically claimed narrow range of Al content is able to yield advantageous effects not disclosed by or expected by JP '128 and that is remarkably and unexpectedly superior to the other portions of the broad range disclosed by JP '128. Applicants further submit that one of ordinary skill in the art could not have foreseen these results based on the teachings of the prior art.

By limiting Al content to be within 6.45 to 11.03 atomic percent (as opposed to 0.02 to 20 atomic percent), the present invention possesses a favorable effect of preventing generation of precipitates in the target and forming a uniform base layer (i.e., seed layer) which is not disclosed, expected or rendered obvious by JP '128. Since JP '128 is only concerned with forming an oxide film by diffusing and condensing Al in the vicinity of the surface of a wire, the results obtained with 6.45 to 11.03 atomic percent of Al is simply not expected and Al content can be 0.02 to 20 atomic percent without expectation of any advantageous use of a more restricted range.

Accordingly, Applicants respectfully submit that the present invention possesses an inventive step (non-obviousness) over JP '128.

(v) Prior Art Fails to Disclose or Obviate Absence of Precipitates

In the FINAL Office Action, it is stated that it is expected "that compounds similar in structure will have similar properties." Applicants respectfully disagree and request reconsideration. Simply because sputtering targets may have similar compositions does not mean that will have "similar structures" or "similar properties".

Independent claims 3 and 7 of the present application require a target "having a structure that does not substantially contain any precipitates", and independent claim 28 requires a sputtering target body "containing no precipitates".

As explained by the specification of the present application (page 5, lines 5-6), when the additive amount of Al exceeds 0.2wt%, "precipitates will arise during the manufacture process of the target." The problem with precipitates is discussed on page 5, lines 7-21, of the present application as follows:

> "When precipitates exist in the target structure, particles will be generated since the sputtering rate between the matrix phase and precipitates phase will differ, and problems such as wiring disconnection in the semiconductor device will occur.
>
> In particular, it has become evident that these precipitates are formed in the center (middle) of the target separate from the surface, and not near the target surface.
>
> Therefore, problems caused by precipitates occur not during the initial phase of sputtering, but from a state in which the erosion of the target caused by sputtering has progressed to a certain degree. In other words, precipitates are caused by minute particles getting mixed into the sputtered film, or due to the micro unevenness of the film composition midway during sputtering.
>
> As a matter of course, since such uneven portions of the seed film generate uneven electric fields, the copper plating film structure will become uneven and minute, and electromigration resistance characteristics will deteriorate, which is obviously unfavorable. Although the problem is often overlooked since it does not occur in the initial states, this is a major problem."

Both cited prior art references fail to disclose any steps taken to eliminate the otherwise normal formation of precipitates within the body of the sputtering target.

Takahashi et al. disclose a sputtering target and thin film wiring having no more than 1 ppm of Al. Thus, since precipitates would not form in the target of Takahashi et al. due to the absence of Al content, there is no common sense reason provided to one of ordinary skill in the art by Takahashi et al. with respect to preventing the formation of precipitates.

JP '128 is almost exclusively directed to a thin film, not a sputtering target nor its method of manufacture. For example, the only reference at all in JP '128 with respect to a sputtering target is in Paragraph No. 0010 of JP '128. This paragraph merely discloses the composition of a copper alloy target and fails to disclose any other characteristic or method with respect to manufacturing the target.

Accordingly, if one of ordinary skill in the art were to follow either prior art reference, either a target without the required Al content would be prepared (i.e. according to Takahashi et al.), or a target having the required composition as well as precipitates would be prepared. There is simply no combination of teachings that would make it obvious to one of ordinary skill in the art to provide a copper alloy sputtering target having 0.2 to 5wt % Al and no precipitates.

With respect to the sputtering target of the present invention, page 6, lines 20-25, of the present application reads, as follows:

> "Further, upon manufacturing the target, after performing homogenization heat treatment with a certain degree of thickness, in the subsequent cooling step, it is important to sandwich this with metals having a large thermal capacity such as copper plates underwater, and to increase the cooling effect without generating a vapor layer on the surface thereof. This is because if a vapor layer is formed, the cooling effect will significantly deteriorate."

This cooling step is discussed with respect to the Examples and Comparative Examples described in the present application. Examples 2-1 and 2-2 and Comparative Examples 2-1 and 2-2 are directed to Cu-Al alloy sputtering targets (see page 7, line 27, to page 8, line 21). As disclosed on page 8, lines 2-5, Example 2-1 was prepared as follows:

> "Thereafter, this was rolled until it became φ 360x10t with cold rolling, heat treatment was performed thereto at 500°C for 1 hour, <u>and this was sandwiched with copper plates under water for forced cooling</u>. Moreover, this was machined processed to obtain a discoid target having a diameter of 13 inches and a thickness of 7mm."

With respect to Example 2-2, the same process steps were utilized as for Example 2-1. With respect to Comparative Examples 2-1 and 2-2, all process steps are identical to that used for Example 2-1, except that underwater cooling was replaced by "cooling in a furnace." For example, see page 8, lines 14-22, which reads as follows:

> "Comparative Example 2-1
>
> Using the same materials as Example 2-1, after performing heat treatment at 500 degrees for 1 hour, this was <u>cooled in a furnace</u>. The <u>other conditions were the same as Example 2-1</u>. As a result, a copper alloy target containing 1.0wt% of Al was prepared.
>
> Comparative Example 2-2
>
> Using the same materials as Example 2-2, after performing heat treatment at 500 degrees for 1 hour, this was <u>cooled in a furnace</u>. The <u>other conditions were the same as Example 2-2</u>. As a result, a copper alloy target containing 0.5wt% of Al was prepared."

Accordingly, Example 2-1 and Comparative Example 2-1 of the present application are identical with the only exception being the process step of underwater cooling between plates versus the process step of cooling in a furnace. The same is true between Example 2-2 and Comparative Example 2-2.

On page 11, in Table 1, the present application reveals that "Precipitates" for Examples 2-1 and 2-2 are "Not Observed". However, Table 1 shows that amounts of "Precipitates" were observed for the Comparative Examples. Keep in mind, the only difference between the Examples and the Comparative Examples was the process step of underwater cooling between plates and cooling in a furnace.

Thus, Applicants respectfully submit that the cited prior taken alone or in combination fail to disclose a sputtering target having the required composition and no precipitates. Applicants also respectfully submit that even though sputtering targets of the same composition may be prepared, it cannot be reasonably expected that these sputtering targets will have the same structure nor the same properties. For instance, compare the results for Examples 2-1 and 2-2 with those for Comparative Examples 2-1 and 2-2 discussed above.

For at least this reason, Applicants respectfully request reconsideration and removal of the obvious rejection of the claims of the present application based on JP '128 in view of the Takahashi et al. reference.

(vi) Prior Art Fails to Disclose or Obviate Claimed Ratio

In the FINAL Office Action, it is stated that it is expected "that compounds similar in structure will have similar properties." Applicants respectfully disagree and request reconsideration. Simply because sputtering targets may have similar compositions does not mean that will have "similar structures" or "similar properties".

Independent claims 3, 7 and 28 of the present application require a target having a ratio I(111)/I(200) of 2.2 or more in the sputtering face of the target. Applicants respectfully submit that the prior art fails to disclose this required limitation.

Page 6, lines 20-25, of the present application reads, as follows:

> "Further, upon manufacturing the target, after performing homogenization heat treatment with a certain degree of thickness, in the subsequent cooling step, it is important to sandwich this with metals having a large thermal capacity such as copper plates underwater, and to increase the cooling effect without generating a vapor layer on the surface thereof. This is because if a vapor layer is formed, the cooling effect will significantly deteriorate."

This cooling step is discussed with respect to the Examples and Comparative Examples described in the present application. Examples 2-1 and 2-2 and Comparative Examples 2-1 and 2-2 are directed to Cu-Al alloy sputtering targets (see page 7, line 27, to page 8, line 21). As disclosed on page 8, lines 2-5, Example 2-1 was prepared as follows:

> "Thereafter, this was rolled until it became φ 360x10t with cold rolling, heat treatment was performed thereto at 500°C for 1 hour, <u>and this was sandwiched with copper plates under water for forced cooling</u>. Moreover, this was machined processed to obtain a discoid target having a diameter of 13 inches and a thickness of 7mm."

With respect to Example 2-2, the same process steps were utilized as for Example 2-1. With respect to Comparative Examples 2-1 and 2-2, all process steps are identical to that used for Example 2-1, except that underwater cooling was replaced by "cooling in a furnace." For example, see page 8, lines 14-22, which reads as follows:

> "Comparative Example 2-1
>
> Using the same materials as Example 2-1, after performing heat treatment at 500 degrees for 1 hour, this was <u>cooled in a furnace</u>. The <u>other conditions were the same as Example 2-1</u>. As a result, a copper alloy target containing 1.0wt% of Al was prepared.
>
> Comparative Example 2-2
>
> Using the same materials as Example 2-2, after performing heat treatment at 500 degrees for 1 hour, this was <u>cooled in a furnace</u>. The <u>other conditions were the same as Example 2-2</u>. As a result, a copper alloy target containing 0.5wt% of Al was prepared."

Accordingly, Example 2-1 and Comparative Example 2-1 of the present application are identical with the only exception being the process step of underwater cooling between plates versus the process step of cooling in a furnace. The same is true between Example 2-2 and Comparative Example 2-2.

On page 16, in Table 6, the present application reveals that the ratio I(111)/I(200) for Examples 2-1 and 2-2 are 2.64 and 2.25, respectively, which are both "2.2 or more" as required

by claims of the present application. However, Table 6 shows that the ratio I(111)/I(200) for the Comparative Examples are 1.73 and 1.21, respectively, which are both outside of the range "2.2 or more" and outside of the scope required by the claims of the present application. Keep in mind, the only difference between the Examples and the Comparative Examples was the process step of underwater cooling between plates and cooling in a furnace.

Accordingly, Applicants respectfully submit that it is an error and it is inaccurate to conclude that sputtering targets made of similar compositions will have the same structure and the same properties.

II. Conclusion

In view of the above amendments and remarks, Applicants respectfully submit that the rejection has been overcome and that the present application is in condition for allowance. Thus, a favorable action on the merits is therefore requested.

Please charge any deficiency or credit any overpayment for entering this Amendment to our deposit account no. 08-3040.

Respectfully submitted,
Howson & Howson LLP
Attorneys for Applicants

By /William Bak/

William Bak
Reg. No. 37,277
501 Office Center Drive
Suite 210
Fort Washington, PA 19034
(215) 540-9216